

HYDROLOGICAL INVESTIGATIONS IN THE SOUTH-WESTERN PART OF THE BARENTS SEA DURING THE SUMMER 1928.

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Summary.

During the summer 1928 hydrologic sections along the 30-th, 35-th and 38-th meridians have been made in the south-western part of the Barents-sea by the expedition of the Marine Scientific Institute on board the ship „Persey“; the same have been reiterated a month later along the 30-th and 35-th meridians. The daily stations were: 1) $\varphi = 76^{\circ} 06' 2''$ N, $\lambda = 30^{\circ} 00' 5''$ E; 2) $\varphi = 73^{\circ} 16' 5''$ N, $\lambda = 38^{\circ} 24' 5''$ E; 3) $\varphi = 77^{\circ} 30'$ N, $\lambda = 30^{\circ} 00'$ E (fig. 1 and 2).

During the whole time at sea soundings have been made every five miles, contributing on one hand to make substantial additions to the bathymetric chart of the Barents-sea (fig. 3) and on the other hand—allowing to find out the connection between the distribution of hydrologic elements and the relief of the bottom.

As fig. 4, 5, 6 and 7 show, each depression of the bottom tallies with a downward curve of the isotherms, whereas each rising of the bottom corresponds with an ascent of the latter; looking downwards the North-Cape current we find that in the hollows all isotherms are pressed up to the right and the rises of the isotherms, the so called „caps of cold water“ appearing over the elevations of the ground, are likewise inclined to the right.

This phenomenon is in an absolute conformity with what has been already pointed out by F. Nansen in his work „The Northern Waters“ (1906), viz. that moving water, swerving to the right under the influence of the earth's rotation, curves its way along the lines of least resistance, i. e. according to the hollows. Over the submarine elevations some kind of islands of calmer and heavier water are being formed.

The temperature of the Barents-sea depends almost entirely upon two causes: upon their cooling in winter and upon the penetration of warmer waters from the Atlantic. In winter the waters of the North-Cape current grow much cooler and the isotherms are smoothed out. In summer warmer waters are falling in, washing off all traces of the winter regime; this action of the North-Cape current is naturally more efficient in places where the current is swifter, namely in the hollows. Consequently, the curve of the isotherms affords the possibility of defining the rate of the North-Cape current: the lower a given isotherm is, the higher is the rate of the current. Over submarine elevations, where the rate of washing off is very small owing to friction, the traces of the winter regime are being detained the longest; this accounts for the origin of „caps of cold water“ over these elevations. The fact that the sections along the 30-th and 35-th meridians have been effectuated twice has permitted to attempt a computation of the rate of the North-Cape current on the base of the temperatures of both sections. This computation is based on the conjecture that the great rises of temperature noticed in summer in the south-western region of the Barents-sea at any depth are chiefly due to the falling in of warm waters from the Atlantic.

According to this conjecture the average temperatures of the sections have been calculated, as well as the variations of these average figures on the same meridian during 24 hours and the variations of the average temperatures from one meridian (gradients) to another on a distance of one km. After dividing the variations (gradients) obtained one by the other, we obtain as a matter of course the average rate of the North-Cape current between the 30-th and 35-th meridians.

The following data have been thus secured;

- 1) The average rate of the North-Cape current is 4.2 cm/sec.
- 2) The rate of the stream in August is higher, then in June.
- 3) The rate of the stream on the 35-th meridian is higher than on the 30-th, which is most natural, the section of the 35-th meridian being smaller.

4) The whole amount of water passing the 30-th meridian does not pass the 35-th. A part of it by a cyclonic movement is reverted to the Atlantic Ocean, being pressed closely to the bank of Bear Island.

This latter circumstance is in full conformity with the fact that on the sections along the 30-th meridian we have a rising of the temperature on these slopes.

All sections effectuated by us have been worked up by means of the dynamic method. The presence of the North-Cape stream has entitled me to avail myself of the dynamic method in a somewhat different manner as it was being used thus far, viz. I considered the North-Cape stream as a river discharging itself into the Barents-sea. The level of the North-Cape stream, similarly to that of any river, must be somewhat inclined under the influence of the deflective force of the earth's rotation and this incline acts upon the distribution of the masses of water. Hence the rate of the current may be obtained. After having computed the rates of the current, dynamic charts of the region involved in our investigation have been traced (fig. 14 and 15). When comparing the average rates of the North-Cape current computed by means of the dynamic method as well as of that of reiterated meridional sections, we see that the rates obtained by means of the former method are much smaller than those obtained by means of the latter. This can be explained in the first place by the fact that in treating the data obtained by means of the dynamic method I was forced to admit that at a depth of 200 m. there was no current at all, whereas we had the opportunity of ascertaining the presence of currents at all depths in the region under investigation.

While working at the daily stations we determined the currents by means of the Ekman current meter. These observations enabled us to specify the elements of constant currents at all depths, the directions and the rates of these currents being in perfect conformity with the data obtained by means of the dynamic calculations.

Investigations of tidal currents resulted in the following statements:

- 1) In open portions of the Barents-sea the tide has a regular semidjurnal period.
- 2) The direction of the tidal currents changes in the direction of the clockpointer in upper and intermediate layers and in the opposite direction—in bottom layers (fig. 16—20).
- 3) The rates of ebb and flow currents are the highest at intermediate depths, namely at a depth of 25—50 m.

At the same daily stations observations were likewise carried on as to the temperature of the water and its salinity at different depths, the following data having been obtained:

- 1) The amplitude of temperaturational variation during 24 hours is large even in bottom layers.
- 2) The amplitude of temperaturational variation in general is larger where the vertical gradient of temperature is larger.
- 3) On all horizons a periodicity of a semidjurnal character can be noticed.
- 4) The variation of temperature may be chiefly imputed to vertical oscillations of water layers.

Fig. 25 shows the course of the isotherm in a certain space of time at our station № 1003. In examining this draught we see that during a day the thickness of the layers between individual isotherms at some times increases and diminishes at others, the increase in the volume of the upper layers being accompanied by a decrease of some in the bottom ones. The amplitude of the rise and fall of individual isotherms reaches in this case 35 m. (table 33).

The comparison of our surveys over temperatures and elements of currents observations at the daily stations proves with full evidence the great vertical oscillations of bottom layers. These oscillations depend upon ebb and flow phenomena. Graphically it may be ascertained by the fig. 27 and 28 showing the position of masses of water under the influence of the deflective force of the rotation of the earth at high water (fig. 27) and at low water (fig. 28).

The study of these draughts leads to the following conclusions:

- 1) The rate of the current decreases generally with the depth. Hence the incline of the isobars and isosters decreases likewise. In every current the layers assume accordingly a wedge-shaped aspect: the distance between the isosters is less in places where these are deeper. In other words, when the isosters rise, the height of the intermediate layers increases (except that of the uppermost ones).

2) The alteration in the height of the layers is accompanied by an additional shifting of masses of water within each layer. This can produce higher velocities in intermediate depths than in upper ones.

The above statements are entirely confirmed by a very simple theory ensuing from the formula:

$$\operatorname{tg} \gamma = \frac{2 \omega \sin \varphi}{g} \left[\frac{C_1 \alpha_2 - C_2 \alpha_1}{\alpha_1 - \alpha_2} \right]$$

in which the angle of inclination of the isoster between two layers whose velocity is equal to c_1 and c_2 is connected with the specific volumes α_1 and α_2 . If the tidal current changes its direction into inverse one, the angle of inclination of the isoster is of course proportionally altered accordingly. The same result has been obtained by means of direct observation at our daily stations.

In the northern parts of our sections and at the section along the edge of the ice (fig. 2) we met „cold intermediate layer“, a phenomenon characteristic for polar seas. The origin of this layer is due to the strong cooling of the water in winter and to its insufficient warming in summer. During winter cooling the upper layers become heavier than those immediately under them, and thus a vertical circulation is originated mixing up the layers to a certain depth. The depth attained by this process of mixing is generally the greater, the stronger the winter cooling is and the smaller the difference of density between individual layers. The greatest depth of the mixed up layers is reached at the very moment, when winter cooling ceases. Usually the whole mixed up layer has a very low temperature; at any rate it is lower than that of the underlying layers.

When summer warming begins, the traces of winter cooling are gradually disappearing from above; in some cases they can be entirely removed, but in most cases (on high latitudes) they remain; this is the phenomenon called „cold intermediate layer“.

During our work we have had the opportunity not only of observing the cold intermediate layer, but also of retracing its gradual disappearance under the action of direct warming and of the North-Cape current.

In some cases, namely when the depth is not great and the layers differ but slightly one from the other as to their salinity, the vertical circulation produced by winter cooling attains readily the bottom; in that case the bottom waters are being ventilated on account of the vertical circulation, this having a high biological value, in particular for the productivity of life at the sea-bottom.

In working up in an appropriate way the hydrologic data of our stations we have been able to demonstrate that the ventilation of bottom waters on the Central Bank of the Barents-sea is much stronger than that on the Perseus Bank, in spite of the circumstance that the latter is situated more to the North and is shallower. This fact is in entire conformity with the productivity of the sea-bottom on the Perseus Bank which is nearly six times smaller than that on the Central Bank.

Simultaneously with hydrologic observations we made researches concerning the transparency and the colour of sea-water. The results of these were as follows:

- 1) At the daily stations fluctuations in transparency of semidjurnal character have been determined.
- 2) Layers at great depths are generally more transparent and more blue.
- 3) The more transparent the water is, the more blue it is (table 43).
- 4) The greater is the specific volume of the water, the less transparent the latter is.

In navigating along the ice-fields we made a survey on the situation of the boundary of the ice-fields and on the rate of its recoiling in different parts of the Barents-sea. These observations, conjointly with those performed previously, induced us to draw the conclusion that the must of the ice formed in the Barents-sea is getting melted in the latter. The main cause of this occurrence is the strong cyclonic motion of the waters of the Barents-sea. In their course to the East along the Murman coast they go up to the North along the Novaya Zemlia, turn to the West along the southern shores of the Franz-Joseph Land and to the South—along the eastern coast of Spitzbergen.

This motion causes the ice to be continually driven, in winter equally, towards Bear Island into the warm waters of the North-Cape current, where it gets melted.